TTCI TECHNOLOGY DIGEST

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Revenue Service Investigation of Unintended Service Braking

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Key Findings:

- No unintended brake applications due to slack action were observed on three manifest trains with head end power operating in a service with a history of train stops in undulating territory. Although this small sample size does not rule out the possibility of unintended brake applications, it suggests that the problem is not pervasive.
- Evaluation of historical train stop data over the test route shows that train separations are sensitive to direction of travel with many incidents concentrated at two specific locations. Also, air problems such as hose separation tend to occur in valleys, presumably as the train moves from a bunched condition into a stretched condition or vice-versa depending on the relative lengths of the train and the grade undulation.

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Transportation Technology Center, Inc. (TTCI) is investigating the root causes of unintended brake-related train stops. The effort described was conducted to determine if any unintended brake applications could be observed on trains running in undulating territory with large numbers of cushioned railcars. The combination of undulating track grades and railcars equipped with long travel cushioning units should provide worst-case conditions for unintended service braking and associated train stops.

If some portion of a train applies service braking at an inopportune time, it could have an anchoring effect leading to large coupler forces and an unintended train stop due to issues such as train separation, broken knuckle, broken coupler, or air hose separation. The phenomenon of unintentional momentary minimum service brake application in a portion of the train has been identified and documented previously on a unit train.[1] The initiating feature was identified as significant slack run-in.

There exist multiple ways in which slack action could potentially cause unintentional service braking on some railcars. Brake control valves are designed to apply and release in reaction to changes in the brake pipe pressure. The air in the brake pipe behaves as a fluid with momentum and the pressure will fluctuate in response to accelerations of the railcars. Controlled slack action testing on a mixed train consist of 63 railcars has demonstrated brake pipe pressure reduction rates as high as 11 psi/second over 75 milliseconds due to the accelerations from slack action.[2]

Other potential scenarios for unintentional service braking involve exercising the end arrangements on cushion-equipped railcars that must accommodate 10 or 15 inches of coupler travel. The motions associated with slack action have anecdotally been observed in some cases to cause coupled end hoses to release air, potentially reducing the brake pipe pressure sufficiently to cause nearby brake valves to apply service braking. Another unintentional service braking scenario could occur if there is substantial brake pipe leakage just behind an end hose or intermediate hose that gets crimped during end arrangement motion.

Canadian National Railway (CN) Kingston Subdivision Undulating Track

The Kingston subdivision runs between Montreal, Quebec and Toronto, Ontario. This line travels through hilly areas causing the track to change from an uphill grade to a downhill grade several times over a relatively short distance. When a train travels over this type of undulating territory portions of the train can be going uphill, while other portions can be going downhill. When a train transitions from an uphill or level grade to a downhill grade, railcars will bunch together (i.e., run-in) as their draft systems are compressed. When a train transitions from a downhill or level grade to an uphill grade, railcars will pull apart, i.e., run out, as their draft systems are put into tension. These run-ins and run outs can cause high in-train forces and are more frequent over the Kingston Subdivision due to the large number of undulations in that track.

Train Stop History

Undulating territory can produce a high number of train interruptions. Common events are broken knuckles/couplers, hose separations, and unintended emergency brake applications. The latter issue is already being managed by supplying train consist data to an industrywide database for trains that can recover brake pipe air pressure without any effort other than to check continuity. Broken knuckles and hose separations require more intervention from the train crew and therefore require a longer duration train stop.

CN provided track elevations and historical train stop data for the test route. TTCI grouped the data from incidents involving broken knuckles, broken drawbars, broken couplers, and opened knuckles together into a single train separation dataset. The train separation data was evaluated based on the direction of travel and the estimated location of the railcar at the time of the failure. These location estimates included input regarding the milepost of the head end of the train after it stopped, the location of the railcar in the train, the length of the train, and assumptions about the stopping distance.

Figure 1 shows the distribution of train separations by milepost for eastbound and westbound trains for 18 months. The relative track elevation data is superimposed on this figure to provide a frame of reference regarding ascending grades, descending grades, and undulations.

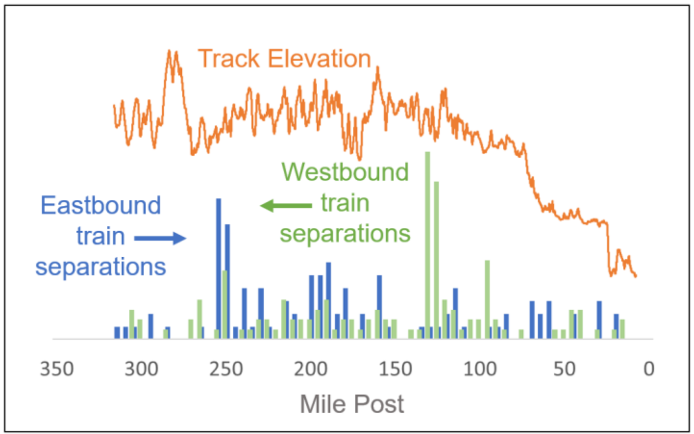

Figure 1. Historical distribution of train separations by milepost for eastbound and westbound trains. Relative track elevations are overlaid for comparison purposes.

The figure shows that train separations are direction sensitive with many incidents concentrated at two specific locations, one for westbound trains in the vicinity of milepost 130 and one for eastbound trains in the vicinity of milepost 255. The reason either of these locations would be especially prone to train separations is not obviously apparent from the track grade data.

In a similar manner, TTCI grouped the data from incidents involving air hose separations, defective air hoses, and defective brake pipes into a single air problem dataset. Figure 2 shows the distribution of air problems by milepost for eastbound and westbound trains for 18 months. In many cases, eastbound and westbound incidents were concentrated in the same or nearby locations. This data indicates that air problems tend to occur in valleys, presumably as the train moves from a bunched condition to a stretched condition or vice-versa depending on the relative lengths of the train and the grade undulation.

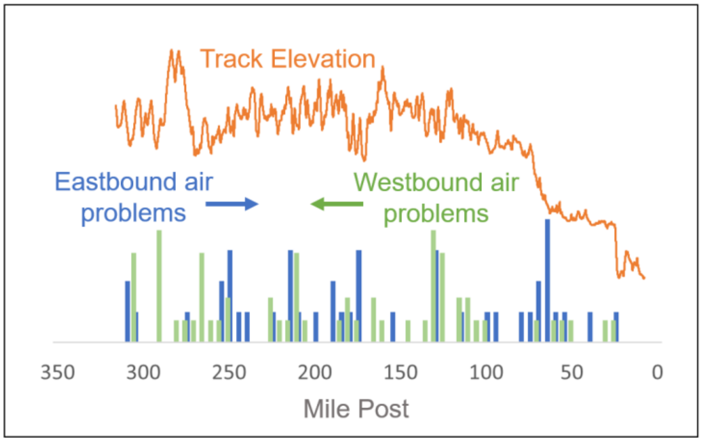

Figure 2. Historical distribution of air problems by milepost for eastbound and westbound trains

Railcars with Long Travel Cushioning Units

Certain railcars are equipped with long travel hydraulic cushioning units in their draft systems. These units act as a damper to lessen the shock of large forces that can be put into a railcar through its coupler. These cushioning units also significantly increase the travel of the draft systems in railcars that they are fitted to. The extra travel in the draft systems can cause a train to increase or decrease significantly in length during run-ins and runouts. The combination of long travel draft systems and undulating territory can result in run-ins and runouts that are more severe. As discussed previously, these run-ins and runouts may cause conditions that could independently activate a railcar's brakes and potentially lead to an unintended train stop.

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Test Setup

This test consisted of affixing pressure sensors to the brake cylinders of various railcars on trains traveling over CN Subdivision. Figure 3 shows one of the pressure sensors spaced periodically throughout the train to capture the behavior of railcar brakes at different locations in the train. This pressure data was then compared to the brake application data from the locomotive event recorder to determine if any railcar brakes had applied without an engineer-initiated reduction in brake pipe pressure. Data was collected for three separate trains. Table 1 summarizes the makeup of these trains.

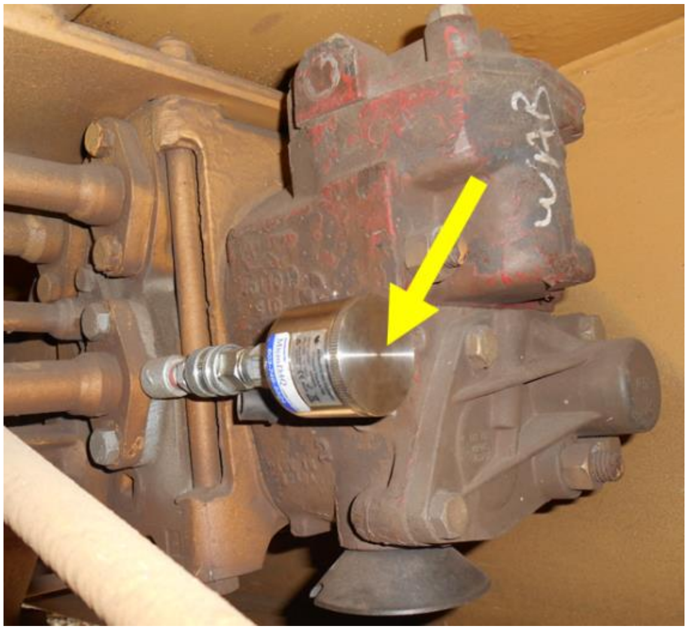

Figure 3. Brake cylinder pressure transducer attached to brake cylinder pressure tap

This test used pressure sensors with built in data loggers to measure the pressure in a railcar's brake cylinder. These pressure sensors were placed on trains consisting of large numbers of railcars with cushioning units, such as auto racks. The sensors were spaced intermittently on the railcars in each train and collected pressure data from the time they were installed until they were retrieved when the train had reached the other end of the line. The pressure loggers were programmed to record absolute pressures at a rate of 1 sample every 2 seconds. After the pressure loggers had been retrieved, the data from the locomotive event recorder was obtained. This locomotive data was compared with the brake cylinder pressure data from various railcars in each train to determine if any unintended brake applications occurred.

Table 1. Test train makeup

	Train 1	Train 2	Train 3
Train number	M73721-19	M37231-20	M37231-22
Direction of travel	Westbound	Eastbound	Eastbound
No. of railcars	98	135	75
Length	8,464 ft.	10,984 ft.	7,330 ft.
Power configuration	Three locomotives, head end	Two locomotives, head end	Four locomotives, head end
Railcar locations with data loggers	53, 57, 61, 66, 71, 75, 80, 85, 90, 95	14, 17, 18, 21, 24, 27, 30, 33, 90	11, 18, 25, 32, 39, 46, 53, 60, 67, 74

Test Results

During this test, data was collected and analyzed for three trains traveling over the Kingston Subdivision. A comparison of the locomotive brake pipe pressure and the railcar's brake cylinders was conducted for each train. These comparisons did not reveal an instance of the railcar brakes activating independently of the locomotive while at line speed. Instances were observed where railcar brakes were active for a prolonged time; but over the same time, brake pipe pressure fluctuated, speeds were low, and the reverser handle was moved. Further investigation of the locomotive event data indicates that these instances represent switching operations. During these switching operations, railcars with the pressure sensors had their brakes applied, while the locomotive made several short moves forward and backward at low speed. These instances do not appear to be unintended brake applications. The comparisons of brake pipe pressure and railcar brake cylinder pressure for each train are shown in Figures 4, 5, and 6. In these figures, brake cylinder pressure has been converted from absolute pressure to gauge pressure for ease of interpretation.

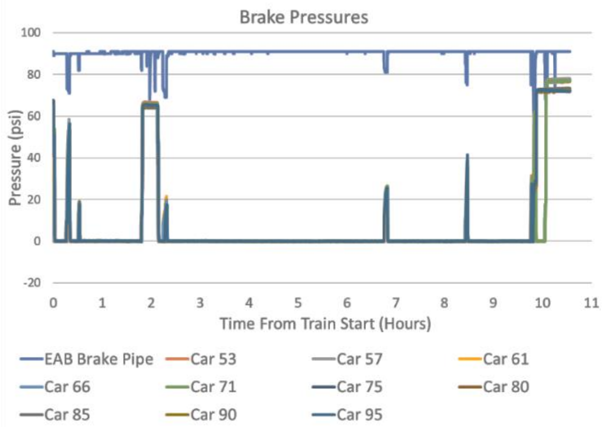

Figure 4. Brake pipe and railcar brake cylinder pressures from first test train (westbound)

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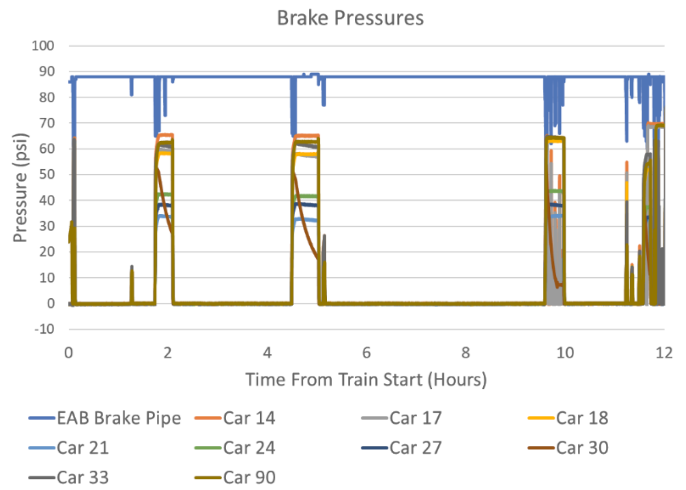

Figure 5. Brake pipe and railcar brake cylinder pressures from second test train (eastbound)

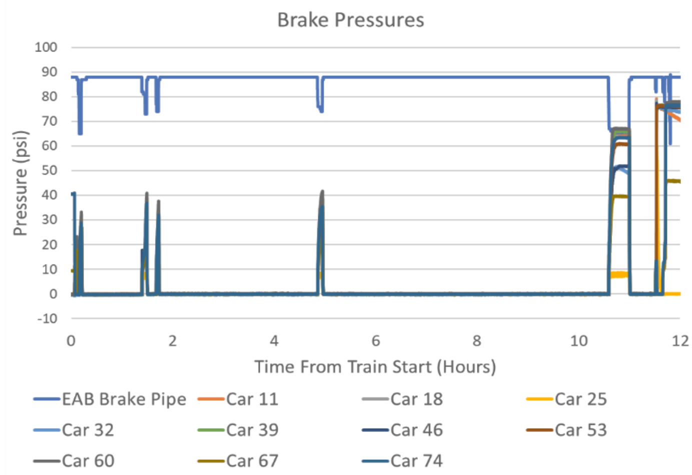

Figure 6. Brake pipe and railcar brake cylinder pressures from third test train (eastbound).

CONCLUSIONS

TTCI investigated the occurrence of unintended air brake applications due to slack action as a root cause of train stops attributed to broken knuckles, air hose separations, and related failure modes. No evidence of unintended air brake activity was found on three trains that each fit multiple worst-case characteristics such as: operating in undulating grades, operating in a service with a history of unscheduled train stops, manifest trains containing blocks of railcars equipped with long travel cushioning units, and head-end power configuration. The lack of evidence of unintended air brake activity found during this testing does not rule out the possibility that it occurs on some trains, but it does suggest that this scenario is not highly pervasive.

A review of 18 months of train stop data over the test route shows that train separations (broken knuckles, broken couplers, open knuckles) tend to occur in two specific locations, one for westbound trains and one for eastbound trains. The track grades in these two locations do not provide an obvious explanation for this phenomenon. Conversely, train air problems (hose separations, brake pipe leakages) tend to occur in similar locations for both westbound and eastbound trains. Many of the air problems occur near locations where the track grades form a valley or sag. This could indicate either train run-ins or runouts depending on several factors including the length of the train, the railcar position in the train, train consist tonnage distribution, and length of nearby descending and ascending grades. Train run-ins suggest peaking of the end hoses as a failure mode, while train runouts suggest end hose pull apart due to tension in the glad hand connection.

ACKNOWLEDGEMENTS

The test team thanks the CN mechanical department employees at both ends of the test route for retrieving the data loggers during inbound inspection.

References

1. AAR Circular Letter C-10169 Subject: Unintentional Momentary Service Brake Applications on Unit Coal Train Equipped with DB-60 Control Valves.
2. DeGeorge, Matt, and S. Cummings. 2018. "Slack Action Effects on Undesired Emergency Brake Applications." *Technology Digest* TD 18-002. AAR/TTCI. Pueblo, CO.

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